

# **Closing the Circle on the Splitting of the Atom**



**Earth contaminated with low-level radioactive waste from the Manhattan Project.** *Hazelwood Interim Storage Site, Latty Avenue, Hazelwood, Missouri. January 29, 1994.*



**Irradiated nuclear fuel in dry storage.** *Building 603, Idaho Chemical Processing Plant, Idaho National Engineering Laboratory. March 17, 1994.*

# **Closing the Circle on the Splitting of the Atom**

The Environmental Legacy  
of Nuclear Weapons Production  
in the United States  
and What the Department of Energy  
is Doing About It

---

The U.S. Department of Energy  
Office of Environmental Management

---



**Radiation-safety technicians check workers** John Bower and Bill Milligan for possible contamination before they exit a Rocky Flats production building now undergoing cleanup. During the Cold War, the Rocky Flats Plant was the primary facility for processing and machining the plutonium used in nuclear weapons. *Rocky Flats Environmental Technology Site, Colorado. March 19, 1994.*

The photographs on pages 12, 18 (right), 31, and 79 are from *AT WORK IN THE FIELDS OF THE BOMB* by Robert Del Tredici. Copyright © 1987 by Robert Del Tredici. Reprinted by arrangement with HarperCollins Publishers. In addition, the photographs on pages 1, 11-14, 16, 37, 39, 58, 59 (number 3), 76, 83 and 100 are copyrighted © by Robert Del Tredici and reprinted with permission by the photographer.



## Letter from the Secretary

*The United States built the world's first atomic bomb to help win World War II and developed a nuclear arsenal to fight the Cold War. How we unleashed the fundamental power of the universe is one of the great stories of our era. It is a story of extraordinary challenges brilliantly met, a story of genius, teamwork, industry, and courage.*

*We are now embarked on another great challenge and a new national priority: refocussing the commitment that built the most powerful weapons on Earth towards the widespread environmental and safety problems at thousands of contaminated sites across the land. We have a moral obligation to do no less, and we are committed to producing meaningful results. This is the honorable and challenging task of the Department's Environmental Management program.*

*Although the war that gave us the atomic bomb ended half a century ago, and the Cold War that followed is now over, the full story of the splitting the atom has yet to be written. **Closing the Circle on the Splitting of the Atom** reveals one of the story's biggest missing pieces. It describes the environmental legacy of nuclear weapons production in the United States and what the Department of Energy is doing about it.*

*This story is being written in laboratories and at waste sites by scientists and engineers grappling with daunting waste and contamination problems. It is being written in state capitols, town halls, and board rooms by government officials, citizens and contractors developing new ways of doing business. And it is being written by tens of thousands of workers dismantling buildings, treating waste, safeguarding plutonium and caring for each other's safety in this dangerous mission.*

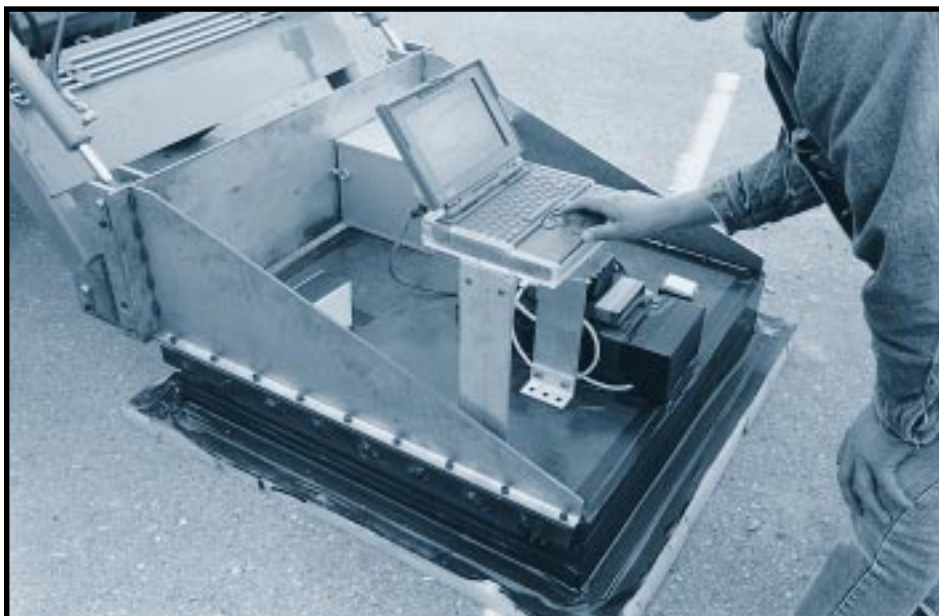
*In 1993 we launched our "Openness Initiative" by coming clean with our past and opening many of our files to the public. We did this to earn public trust and foster informed public participation in Government decisionmaking. This book will help advance this critical obligation by illuminating the challenges and accomplishments of nuclear weapons facilities cleanup and putting a human face on the work being done to close the circle on the splitting of the atom.*



Hazel R. O'Leary  
Secretary of Energy







The long-range alpha detector is highly sensitive to alpha radiation. This breakthrough in radiation monitoring picks up trace ions formed in air by alpha particles at a distance of several meters, allowing fast screening with quick results. *Los Alamos, New Mexico. February 24, 1994.*

# Table of Contents

---

<i>Letter from the Secretary</i> .....	v
<i>Introduction</i> .....	ix
<b>I. Overview</b> .....	<b>1</b>
The Manhattan Project .....	1
The Cold War and the Nuclear Weapons Complex .....	2
Civilian Control .....	4
Environmental Legacy of the Cold War .....	4
Environmental Management .....	5
Closing the Circle .....	9
The Challenges Before Us .....	9
<b>II. Building Nuclear Warheads: The Process</b> .....	<b>11</b>
Special Nuclear Materials .....	12
Uranium Mining .....	13
Uranium Milling.....	13
Uranium Enrichment .....	14
Uranium Metallurgy .....	15
Plutonium Production .....	16
Extraction of Special Nuclear Materials .....	18
Plutonium Metallurgy .....	19
Weapons Design .....	20
Final Assembly .....	20
Testing .....	21
<b>III. Wastes and Other Byproducts of the Cold War</b> .....	<b>23</b>
Spent Nuclear Fuel .....	26
Reducing Risks from Spent-Fuel Storage .....	28
Options for the Long-Term Storage and Disposal of Spent Fuel .....	29
High-Level Waste from Reprocessing .....	30

Reducing Risks from High-Level Waste .....	31
Stabilizing High-Level Waste: Preparing for Disposal .....	34
Progress in Idaho .....	35
Converting Waste to Glass in South Carolina, New York, and Washington .....	36
The Evolution of Health Protection Standards for Nuclear Workers .....	38
Radiation and Human Health .....	39
The Plutonium Problem .....	40
Plutonium Residues and Scraps .....	41
Plutonium Metal in Storage .....	42
Informed Debate About Disposition .....	43
Transuranic Waste .....	44
Progress in Managing Transuranic Waste .....	45
Permanent Disposal .....	45
Low-Level Radioactive Waste .....	48
Newly Generated Low-Level Waste .....	49
Managing Low-Level Waste .....	49
Hazardous Waste .....	52
Mixed Hazardous and Radioactive Waste .....	53
Other Materials in Inventory .....	56
Waste-Handling Complications .....	58
<b>IV. Contamination and Cleanup.....</b>	<b>61</b>
Actions in Cleanup .....	62
Deciding When and How To Take Action .....	62
Progress in Cleanup .....	64
Challenges To Be Met .....	65
Improving Performance .....	67
Moving Forward .....	70
<b>V. An International Perspective.....</b>	<b>75</b>
Worldwide Cooperation .....	76
Safe Management of Nuclear Materials .....	76
New Attitudes .....	77
<b>VI. Transition to New Missions.....</b>	<b>79</b>
Engineering Challenges .....	79
Institutional Challenges .....	80
Need to Know .....	81
From Secrecy to Openness .....	81
Whistleblowers .....	82
Citizen Involvement .....	82
Contract Reform .....	82
<b>VII. Looking to the Future.....</b>	<b>85</b>
Providing for Broad-Based Debate and Participation .....	85
Strategy Before Action .....	86
Reconciling Democratic Involvement with Institutional Efficiency .....	90
The Long-Term Vision for Environmental Management .....	90
What Might Future Generations Question? .....	90
Closing the Circle on the Splitting of the Atom .....	91
<i>Glossary.....</i>	<i>93</i>
<i>For Further Reading.....</i>	<i>101</i>



## Introduction

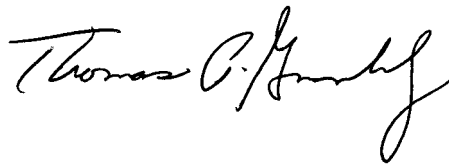
*In the grand scheme of things we are a little more than halfway through the cycle of splitting the atom for weapons purposes. If we visualize this historic cycle as the full sweep of a clockface, at zero hour we would find the first nuclear chain reaction by Enrico Fermi, followed immediately by the Manhattan Project and the explosion of the first atomic bombs. From two o'clock until five, the United States built and ran a massive industrial complex that produced tens of thousands of nuclear weapons. At half past, the Cold War ended, and the United States shut down most of its nuclear weapons factories.*

*The second half of this cycle involves dealing with the waste and contamination from nuclear weapons production – a task that had, for the most part, been postponed into the indefinite future. That future is now upon us.*

*Dealing with the environmental legacy of the Cold War is in many ways as big a challenge for us today as the building of the atomic bomb was for the Manhattan Project pioneers in the 1940s. Our challenges are political and social as well as technical, and we are meeting those challenges. We are reducing risks, treating wastes, developing new technologies, and building democratic institutions for a constructive debate on our future course.*

*The course of the environmental management program will be decided through broad public debate – both national and local. Where and how will we treat and dispose of the backlog of wastes from nuclear weapons production? How clean is clean? Should we exhume large volumes of contaminated soil in order to allow for unlimited use of the land in the future? Is plutonium a waste or a resource? To foster a sustained and informed public debate on these and other critical questions, we created this book. In it we use photographs as well as facts and figures, because only this combination can begin to convey the scale, the complexity, and the reality of the legacy we face, and the successes we have achieved so far.*

*Our hope is that this book will promote and inform broad-based citizen involvement so that we can move forward together in this difficult and compelling work.*



**- Thomas P. Grumbly,**  
Assistant Secretary for Environmental  
Management, U.S. Department of Energy



